## II. "On a Thermopile and Galvanometer combined." By Professor GEORGE FORBES, M.A. Communicated by Lord RAYLEIGH, M.A., D.C.L., Sec. R.S. Received February 4, 1886.

The author has lately made use of a special form of thermopile and galvanometer combined, which is very sensitive for the measurement of radiation. The apparatus is especially suitable for use as a line-thermopile.

The first experiments were made with two half tubes, one of antimony the other of bismuth, soldered together so as to make a short tube about 2 cm. external diameter, the walls being 2 mm. thick, and the length of tube about 2 or $2\frac{1}{2}$ cm. The sides of the tube where the junctions of the metals occur were then filed flat, so as to present a thin wall to receive the radiations and to enable it to rise in temperature more rapidly, and also more uniformly throughout the thickness of this wall. This tube was lamp-blacked. A Thomson's mirror and magnets (by J. White, of Glasgow), in its usual brass cell, but with an insulated coating, was then inserted in the tube, and the whole apparatus mounted inside a brass cube with a brass cone at one side to throw the radiations upon one junction, and with a circular hole facing the mirror. This apparatus when properly adjusted with a lamp and scale was found to be very sensitive. It had been the intention of the author to use a telescope in place of a lamp, but the radiations of the lamp were found to give rise to no inconvenience.

Let us compare the probable sensitiveness of this instrument, say, with a line-thermopile of the ordinary construction of 20 pairs, forming a line of the same length as the tube, the double length of a pair of antimony and bismuth in the line-thermopile being equal to the circumference of the tube. Let E be the E.M.F. of one junction, and let R be the resistance of one pair in the line-thermopile, and let R′ be the resistance of the galvanometer used with the line-thermopile. The total resistance of the line-thermopile is 20R, and that of the tubular one is $\frac{R}{20}$, and the currents in the line and tubular thermopiles respectively are $\frac{20E}{20R+R'}$ and $\frac{20E}{R}$. If the galvanometer were specially constructed to match the line-thermopile, R′ would be made equal to 20R, and the current would be $\frac{E}{2}$, or one-fortieth of the current in the tubular thermopile and galvanometer combined. Thus it would require forty turns of wire in the low-resistance galvanometer, if these coils occupied the same space as the metal of the tubular

thermopile, to equal the sensitiveness of the latter, and a larger number if it occupied a greater space. On the whole, it seems probable that by specially designing a galvanometer to match the line-thermopile the arrangement would be about as sensitive as the new instrument in the form hitherto described, but the simplicity and cheapness of construction of the latter commends it.

The next apparatus was made according to the following instructions:—

Take a wedge whose distance from the apex to the base is about 6 cm., the base of the triangular section of the wedge being about 3 cm., and the width of the wedge 6 cm. The wedge is half of antimony and half of bismuth, the division being made by the medial plane perpendicular to the three rectangular faces of the wedge cut off the apex of the wedge by a plane parallel to the base of the wedge, and exposing a surface of $1\frac{1}{2}$ cm. width. This is the surface which receives the radiations, and it is lamp-blacked. A hole about 1 cm. diameter is now drilled (or it is better to file it out before the two metals are soldered together) through the two sides of the wedge, so as to leave only a thin wall along the junction of the metals at the surface which receives the radiations. A Thomson cell with suspended mirror and magnet is inserted in this hole and the instrument is complete, and ready to be placed inside the brass box with cone already described.

The resistance of this cell is very low and its sensitiveness thereby increased. Moreover this type has a great advantage in the fact that the mass of metal acts as a damper upon the vibrations of the magnet, and so we have a dead-beat instrument.

The diameter of the cone to receive radiations at its mouth was 5 cm. A candle at a distance of 30 cm. from the mouth of the cone gave a deflection of 52 divisions, a reading being easily made correct to one division. A duplex lamp burning paraffin oil at a distance of $1\frac{1}{2}$ metres gave a deflection of 60 divisions.

The author takes this opportunity to describe a method of carrying the delicate Thomson cells without danger of breaking the silk fibre suspension. The cell consists externally of a brass tube. A horse-shoe magnet is obtained with the distance between its legs small compared with the diameter of the above-mentioned tube. The tube is placed so as to rest on the inner edges of the legs of the magnet, with the mirror over the poles of the magnet, the mirror magnets having their poles over poles of opposite name of the horse-shoe magnet, and with the silk fibre next to the magnet. The mutual magnetic attraction takes the tension off the silk fibre and holds the mirror fixed in position, and the fibre cannot be broken by a blow given to the apparatus.

Fig. 1 is a sketch of the first arrangement in the form of a tube.

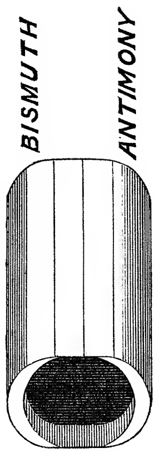


Fig 1.

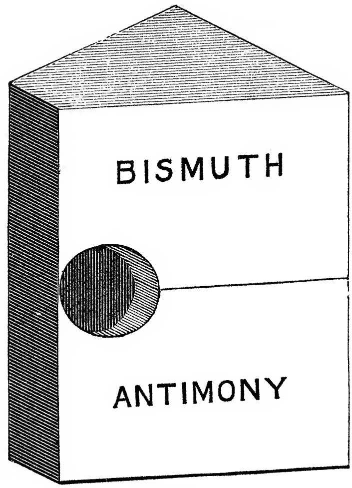


Fig. 2.

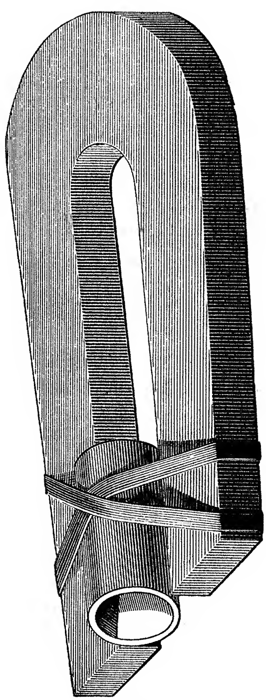

Fig. 3.

Fig. 2 is a sketch of the low-resistance combination, showing the hole into which the Thomson cell is inserted.

Fig. 3 shows the portable arrangement to prevent fracture of the silk suspension.

*February* 25, 1886.

Professor STOKES, D.C.L., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read:—

## I. "On a Comparison between Apparent Inequalities of Short Period in Sun-spot Areas and in Diurnal Declination-ranges at Toronto and at Prague. By BALFOUR STEWART, M.A., LL.D., F.R.S., and WILLIAM LANT CARPENTER, B.A., B.Sc. Received February 17. Read February 25, 1886.

1. In a report to the Solar Physics Committee ("Proc. Roy. Soc.," vol. 37, p. 290, 1884) we discussed the relations between certain apparent Inequalities of short periods in sun-spot areas on the one hand and diurnal temperature-ranges at Toronto and at Kew of corresponding periods on the other.

In the present communication we proceed to discuss the connexion between the same solar Inequalities and the diurnal declination-ranges at Toronto and at Prague.

For the Toronto declination-ranges we are indebted to the kindness of the Science and Art Department, South Kensington, and of Mr. Carpmael, Director of the Toronto Observatory, through whom we have received daily values (excluding Sundays) of the diurnal range of magnetic declination at Toronto extending from 1856 to 1879 inclusive, and thus forming a series of 24 years.

Each number is the difference in scale-divisions of the declinometer between the greatest eastern and the greatest western deflection of the declination magnet on each day, as observed at the hours 6 A.M., 8 A.M., 2 P.M., 4 P.M., 10 P.M., and midnight of Toronto mean time, one scale-division of the instrument being equal to 0′·72 nearly. It is probable that such differences represent very nearly the true diurnal range.

Disturbances appear to be violent at Toronto, and we have rejected

Fig 1.

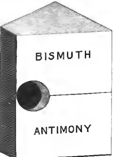


Fig. 2.

Fig. 3.